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(71) Applicant: **Advanced Microwave Engineering di Salvador Claudio e C. S.a.s.**
50018 Scandicci, (prov. of Firenze) (IT)

(72) Inventors:
- **Salvador, Claudio**
  50018 Scandicci (FI) (IT)
- **Biffi Gentili, Federico**
  50141 Firenze (IT)

(74) Representative: **Gervasi, Gemma, Dr.**
Notarbartolo & Gervasi S.p.A.,
Corso di Porta Vittoria, 9
20122 Milano (IT)

(54) **Dual band transponder system**

(57) Transponder system comprising an interrogating device (BOA) and at least one responding device (TAG) in a bi-directional cable-less communication, where the interrogating device (BOA) and the at least one responding device (TAG) are provided with means for communicating through two distinct transmission channels, one channel for the activation, by the interrogating device (BOA), of a responding device (TAG) present in a preset activation area (MFP), the other channel, bi-directional, for data exchanging between the interrogating device (BOA) and a responding device (TAG) positioned within a data exchange area (RFP).

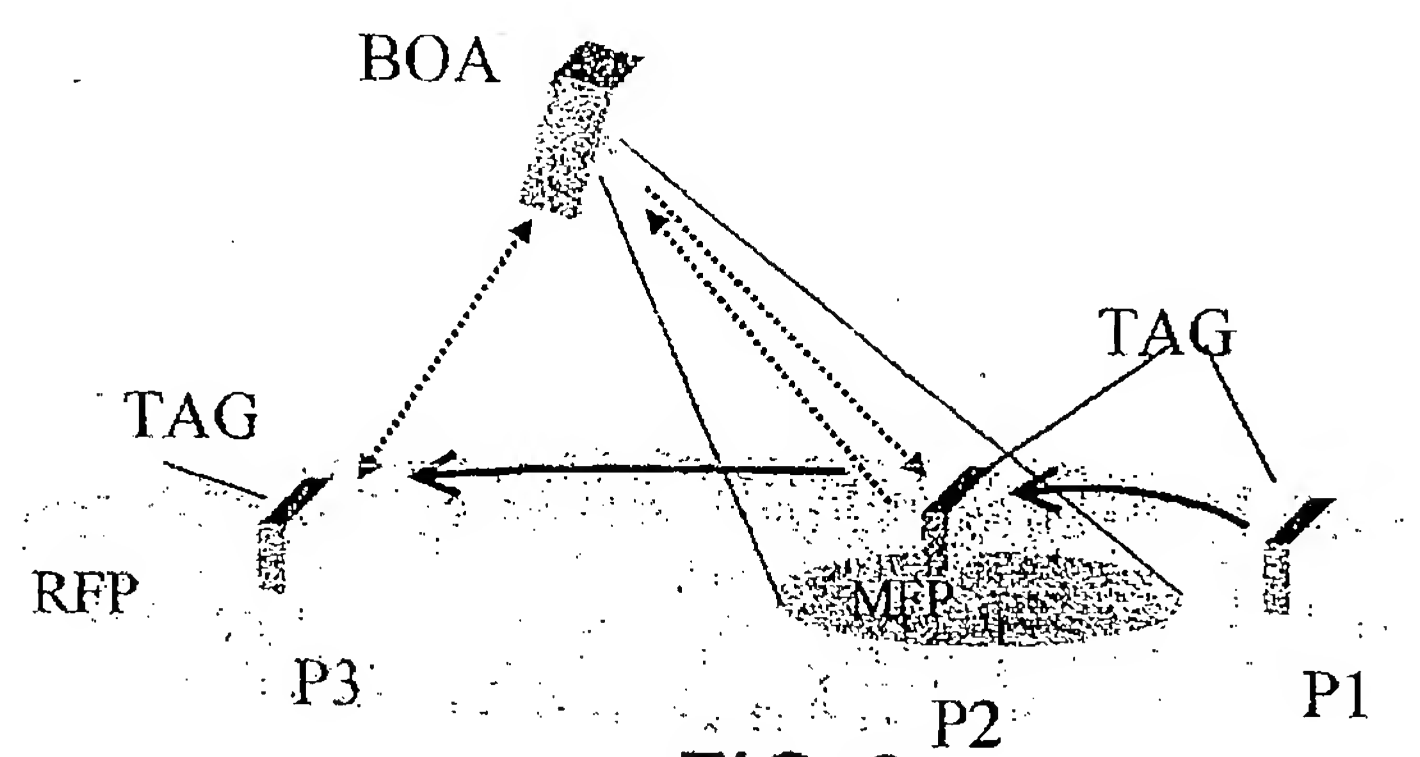

FIG. 2

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Description

Field of the invention

[0001] The invention consists of a dual band responder system, hereinafter identified with the word "transponder".

[0002] More particularly, the invention refers to a dual band transponder for data exchange between an interrogating device, also called "BOA" or "reader", and one or more responding devices, called "TAG", present within the useful radius (or "range") of the interrogating device BOA.

Prior art

[0003] At the present, transponders of known type use a radio transmission channel which may be a low frequency, a radio frequency or a microwave channel, depending on the application of the system and on the reference standards.

[0004] Among these, low frequency transponders are the most widespread because of their limited cost, but they work only at short distances (a few tens of centimetres) because they use an inductive coupling between the interrogating device BOA and the responding devices TAG.

[0005] Low frequency transponders are used prevalently for identification uses without contact. The short-distance inductive coupling allows the responding devices TAG to be energised directly through the interrogating device BOA, without using battery power supply.

[0006] Radio frequency transponders work on larger distances (up to a few metres) thanks to the coupling between the interrogating device BOA and the responding devices TAG and are used for remote identification, but the responding devices TAG require battery power supply.

[0007] Microwave transponders are the technologically most advanced application and overall they offer the best performance, being characterised by high-speed data exchange over distance of some tens of metres.

[0008] However, microwave transponders present various drawbacks which strongly limit their use, in particular the complexity and the high cost for realising the interrogating device BOA and the complex standards linked with the high power of the signal emitted by the interrogating device BOA.

[0009] Further limits of the transponder systems of the prior art are due to the nature of the communication between the interrogating device BOA and the responding device TAG, which is articulated between a state of latency in which the responding device TAG is active only when receiving the signals coming from the interrogating device BOA and a state of activity into which the responding device TAG passes when it is within the activity range of the interrogating device BOA. The mono-directional or bi-directional exchange of data between the interrogating device BOA and the responding device TAG occurs within the above activity range.

[0010] When the responding device TAG passes from latency to activity state (awakening), it is necessary that the communication occurs with high spatial discrimination so as to avoid conflicts between different responding devices TAG and to interrogate only one responding device TAG at a time.

[0011] Moreover, at the moment of the passage to the activity state, the responding device TAG concerned must have at its disposal a so long "time window" to allow the ending of the started transaction (i.e. the data exchange between the interrogating device BOA and the responding device TAG) which, depending on the application, may be mono-directional or bi-directional and more or less consistent.

[0012] A serious limit of the known transponders is therefore the fact that, by using the same transmission channel (or "layer") for activating the responding device TAG and for the communications between the responding device TAG and the interrogating device BOA and vice versa, the range of activation of the responding device TAG practically coincides with the range of communication, resulting in poor operative flexibility.

Scope of the invention and summary

[0013] The principal scope of the present invention is to overcome the limits of the transponder systems of the prior art.

[0014] A particular scope of the invention is to provide a transponder system where the activation radius of the responding devices TAG may be controlled independently from the communication radius (range) and at the same time where the responding device TAG requires an extremely limited energy.

Summary of the invention.

[0015] These scopes have been achieved with a transponder system according to the enclosed claims.

List of drawings.

[0016] The advantages obtained will be clear from the following description and from the enclosed drawings, in which:

- Fig. 1 schematically shows the coupling of an interrogating device and of a responding device according to the invention;
- Fig. 2 shows a block diagram of the transponder system realised according to the invention;
- Fig. 3 shows a circuit diagram of a responding device belonging to the claimed system.

Detailed description of the invention

[0017] A transponder system according to the invention comprises an interrogating device BOA and at least one responding device TAG (one in figure 1) connected by a bi-directional cable-less communication system, where the interrogating device BOA and the at least one responding device TAG are provided with means for communicating through two distinct channels (L1, L2; figure 1), one of which (L1) allows the activation by the interrogating device BOA of a responding device TAG present in an activation area MFP while the other channel (L2) is bi-directional and allows the data exchange between the interrogating device BOA and a responding device TAG positioned within a data exchange area RFP.

[0018] With reference to figure 1, the interrogating device BOA and the responding device TAG communicate through two distinct, not interfering transmitting channels (L1, L2), where L1 is a microwave transmitting channel which activates the responding device TAG while L2 is a radio frequency transmitting channel for bi-directional data exchange between the interrogating device BOA and the responding device TAG.

[0019] Two antennae (B1, B2) belonging to the interrogating device BOA and two antennae (T1, T2) belonging to the responding device TAG are corresponding to the two transmitting channels (L1, L2).

[0020] The antenna B1 associated with the microwave transmitting channel L1 is characterised by a high directivity so as to obtain the desired spatial discrimination during the activation phase of the responding device TAG, while the antenna B2 corresponding to the radio frequency transmitting channel L2 is preferably an omnidirectional antenna, so as to allow a wide-range communication and without limits of reciprocal orientation between the interrogating device BOA and the responding device TAG.

[0021] The microwave activation channel L1 is a microwave signal emitted by an oscillator OM (belonging to the interrogating device BOA) by means of the antenna B1 belonging to the interrogating device BOA and received by a microwave detector RL (belonging to the responding device TAG) by means of the antenna T1 belonging to the responding device TAG.

[0022] The microwave activation signal emitted by the oscillator OM belonging to the interrogating device BOA may be variously modulated so as to avoid accidental activation by isofrequential disturbing sources or to create an information carrier.

[0023] Without diverting from the scope of the present invention, the activation signal can be a millimetric wave signal or an optical frequency signal.

[0024] The data exchange channel L2 is a radio frequency signal exchanged between a transceiver RF1 (belonging to the interrogating device BOA) by means of the antenna B2 belonging to the interrogating device BOA and a transceiver RF2 (belonging to the responding device TAG) by means of the antenna T2 belonging to the responding device TAG.

[0025] In greater detail and still with reference to figure 1, an interrogating device BOA realised according to the invention comprises a microwave oscillator OM, a radio frequency transceiver RF1, a microprocessor unit MP and software SW which drives the sending of the microwave signal, manages the transceiver RF1 and can perform a number of accessory and control functions.

[0026] Preferably, the interrogating device BOA is also provided with analogical interface ports (for example a serial port RS connected to the microprocessor MP) and with logic ports for signalling, respectively, the presence of a responding device TAG in the activation area and the occupation state of the microwave transmitting channel L1 and/or of the radio frequency transmitting channel L2.

[0027] It is also possible to provide an input (not shown in figure 1) for an activation signal for "multilane" applications, which may be time division ones.

[0028] The interrogating device BOA comprises (or can comprise) at least one activation section physically separated and independent from at least one transceiver section RF but, without diverting from the scope of the present invention, the interrogating device BOA can comprise several transceiver sections RF physically separated from one another and distributed in the region around the interrogating device BOA.

[0029] The responding device TAG in turn comprises a control logic or microcontroller MC, a transceiver RF2 controlled by the microcontroller MC and a microwave detector RL connected to the microcontroller MC and apt to activate the data exchange with the interrogating device BOA.

[0030] Preferably, it is possible also to have a serial port RS or an equivalent interface.

[0031] With reference to figure 2, there are shown a interrogating device BOA, some positions of a responding device TAG and the activation (MFP) and data exchange areas (RFP) which the antennae B1 and B2 belonging to the interrogating device BOA intercept, respectively, on a horizontal reference plane along which the responding device TAG may be shifted.

[0032] The activation area MFP has an approximately elliptical shape and is enclosed within the data exchange area RFP, which is larger and approximately circular in shape.

[0033] With reference to figure 3, a possible embodiment of a dual band responding device TAG belonging to the system to which the present invention refers is shown.

[0034] The responding device TAG comprises two separated printed circuits, (A, B).

[0035] The printed circuit A is a single-side circuit comprising a planar antenna T1 with a rectangular patch which is coupled, through a slot F made on the ground plane of the circuit realised on the printed circuit B, to

the circuit section of the responding device TAG.

[0036] The printed circuit B, on the side opposite to the slot F, contains the circuit section of the responding device TAG.

[0037] In detail, the circuit section of the responding device TAG realised on the printed circuit B comprises:

- an adapting network R, connected to the planar antenna T1, to which a microwave detector RL is connected;
- a control logic LC;
- the transceiver RF2 and the relevant antenna T2.

[0038] Without departing from the scope of the present invention, the responding device TAG is realised on a single printed circuit wherein the planar antenna T1 with a rectangular patch, coupled to the circuit section of the responding device TAG are realised.

[0039] The microwave detector RL comprises a microwave detecting diode connected at the output to a comparator CM which emits an activation signal for the responding device TAG when the level of the continuous voltage sent to the comparator CM by the microwave detector RL reaches a preset comparison value.

[0040] The output signal of the comparator CM is managed by the control logic LC belonging to the responding device TAG for the passage of the responding device TAG to activation status.

[0041] The logic LC also manages mono-directional or bi-directional communication on the radio frequency transmitting channel L2 by means of the transceiver RF2 and the antenna T2.

[0042] Preferably, the activation signal coming from the comparator CM may be made available to an output O for activating external circuits, if any.

[0043] Now, with reference to figure 2, the operation of the system according to the invention is described as an example.

[0044] Initially the responding device TAG is in position P1, within the area RFP covered by the antenna B2 (data exchange area) but outside the activation area MFP: in this position P1 no data exchange takes place and the responding device TAG is in a status of latency.

[0045] When the responding device TAG is within the activation area MFP of the microwave antenna B1 of the interrogating device BOA (position P2), the detecting diode of the responding device TAG receives the microwave signal coming from the interrogating device BOA and transfers it to the comparator CM.

[0046] When the level of the continuous voltage sent to the comparator CM reaches a preset comparison value, the comparator CM emits a signal which reaches the control logic LC which manages the passage of the responding device TAG to the activation status.

[0047] In the activation status the responding device TAG is able to communicate with the interrogating device BOA by using the transmitting channel RF.

[0048] When the responding device TAG replies on the transmitting channel RF the interrogating device BOA may temporarily interrupt the microwave interrogation, preventing the accidental activation of other responding devices TAG.

[0049] The microwave emission by the antenna B1 restarts at the end of a pause period of such duration to allow the ending of the interrogating device BOA-responding device TAG transaction.

[0050] Once the transaction is ended, the responding device TAG automatically goes into a latency period in which the reply to an interrogation remains inhibited. The above strategy practically allows to avoid any conflict between different responding devices TAG which are within the activation area MFP at the same time.

[0051] Preferably, the logic outputs of the interrogating device BOA, which respectively indicate the presence of a responding device TAG in the MFP area and the engaged status of the radio frequency transmitting channel L2, can be used to control access barriers or traffic lights, if any.

[0052] From the above it is clear that the system proposed presents numerous advantages, among which:

- a greater operative range, in the data exchange phase, with respect to single frequency, radio frequency or microwave systems;
- a greater immunity from fading on the communication channel, due to the use of a relatively low frequency carrier;
- simplicity and compactness of the interrogating device BOA, which may be easily realised in a portable or hand-held version, due to the use of very compact antennae;
- simplicity and reliability of the operating logic which eliminates the possibilities of conflict in the replies of different responding devices TAG;
- limited powers of emission both on the microwave transmitting channel L1 and on the radio frequency transmitting channel L2, all to the advantage of the respect of the standard limits;
- "transparent" data exchange without intermediate buffers, with speeds of up to 100 Kb a second, limited only by the RF band width, set by the LPD standard (Low Power Devices);
- easiness of interfacing the interrogating device BOA with a Personal Computer;
- the system is suitable to be used for embodiments including only one interrogating device BOA (single Lane) or several interrogating devices BOA (Multilane), without limiting the number of responding devices TAG for the identification and the data exchange.

[0053] The present invention has been described with reference to a preferred embodiment, but it is understood that equivalent modifications may be made by any skilled person without departing from the field of protection granted by the present patent.

[0054] In particular the transponder may be realised integrating antennae and circuits on a single printed circuit.

[0055] For activation, a transmitter with millimetric waves or, in case, a transmitter operating at optic frequencies may be used instead of a microwave transmitter.

[0056] The receiving section of the transponder will have therefore to be modified by using a millimetric wave diode or a photodiode instead of a microwave diode.

Claims

1. Transponder system comprising an interrogating device (BOA) and at least one responding device (TAG) connected by a bi-directional cable-less communication system, **characterised in that** said interrogating device (BOA) and said at least one responding device (TAG) are provided with means for communicating through two distinct channels (L1, L2), one of which (L1) for the activation by the interrogating device (BOA) of a responding device (TAG) present in an activation area (MFP), the other (L2), bi-directional, for exchanging data between the interrogating device (BOA) and a responding device (TAG) positioned within a data exchange area (RFP).

2. System according to claim 1, **characterised in that** the activation channel (L1) is a microwave signal emitted by an oscillator (OM) belonging to the interrogating device (BOA) by means of a first antenna (B1) belonging to the interrogating device (BOA) and received by a microwave detector (RL) belonging to the responding device (TAG) by means of a first antenna (T1) belonging to the responding device (TAG).

3. System according to claim 2, **characterised in that** the microwave activation signal emitted by the oscillator (OM) belonging to the interrogating device (BOA) may be variously modulated so as to avoid accidental activation by isofrequential disturbing sources or to create an information carrier.

4. System according to claim 1, **characterised in that** the activation signal is a millimetric wave signal or an optical frequency signal.

5. System according to claim 1, **characterised in that** the data exchange channel (L2) is a radio frequency signal exchanged between a transceiver (RF1) belonging to the interrogating device (BOA) by means of a second antenna (B2) belonging to the interrogating device (BOA) and a transceiver (RF2) belonging to the responding device (TAG) by means of a second antenna (T2) belonging to the responding device (TAG).

6. System according to claim 1, **characterised in that** the interrogating device (BOA) comprises a microprocessor unit (MP), a radio frequency transceiver (RF1), a microwave oscillator (OM) and software (SW) running on the microprocessor unit (MP) which drives the sending of the microwave signal by the microwave oscillator (OM) and manages the radio frequency transceiver (RF1).

7. System according to claim 6, **characterised in that** the interrogating device (BOA) is also provided with at least one serial port (RS) connected to the microprocessor unit (MP) and with logic ports for signalling, respectively, the presence of a responding device (TAG) in the activation area (MFP) and the engagement status of the microwave channel (L1) and/or of radio frequency channel (L2).

8. System according to claim 6, **characterised in that** the interrogating device (BOA) is further provided with an input for an activation signal in "multilane" applications.

9. System according to claim 1, **characterised in that** the at least one responding device (TAG) comprises at least one microcontroller (MC), a radio frequency transceiver (RF2) controlled by the at least one microcontroller (MC) and a microwave detector (RL) connected to the at least one microcontroller (MC) and apt to activate the data exchange with the interrogating device (BOA).

10. System according to claim 9, **characterised in that** the microwave detector (RL) comprises a microwave detecting diode connected in turn at the output to a comparator (CM) which emits an activation signal for the at least one responding device (TAG) when the level of the continuous voltage sent to the comparator (CM) from microwave detector (RL) reaches a preset comparison value.

11. System according to claim 10, **characterised in that** the output signal of the comparator (CM) is managed by a control logic (LC) belonging to the at least one responding device (TAG) for the passage of the at least one responding device (TAG) to activation status.

12. System according to claim 9, **characterised in that** the at least one responding device (TAG) comprises two separated printed circuits (A, B), one of which (A) is a single-side circuit comprising a planar antenna (T1) with a rectangular patch which is coupled, through a slot (F) made on the ground plane of the second printed circuit (B), to the circuit section

of the responding device (TAG), which is realised on the side of the second printed circuit (B) opposite to the slot (F).

13. System according to claim 12, **characterised in that** the circuit section of the responding device (TAG) realised on the printed circuit (B) comprises:

    - an adapting network (R), connected to the planar antenna (T1), to which the microwave detector (RL) is connected;
    - the control logic (LC);
    - the transceiver (RF2) and the relevant antenna (T2).

14. System according to claim 9, **characterised in that** the at least one responding device (TAG) is realised on a single printed circuit wherein a planar antenna (T1) with a rectangular patch, coupled to the circuit section of the at least one responding device (TAG), are realised.

15. System according to claim 10, **characterised in that** an output (O) of the activation signal emitted by the comparator (CM) to control external circuits, if any, is provided.

16. System according to claim 1 **characterised in that** the interrogating device (BOA) comprises at least one activation section physically separated and independent from at least one transceiver section (RF).

17. System according to claim 16 **characterised in that** the interrogating device (BOA) comprises several transceiver sections (RF), physically separated from one another and distributed in the region around the interrogating device (BOA).

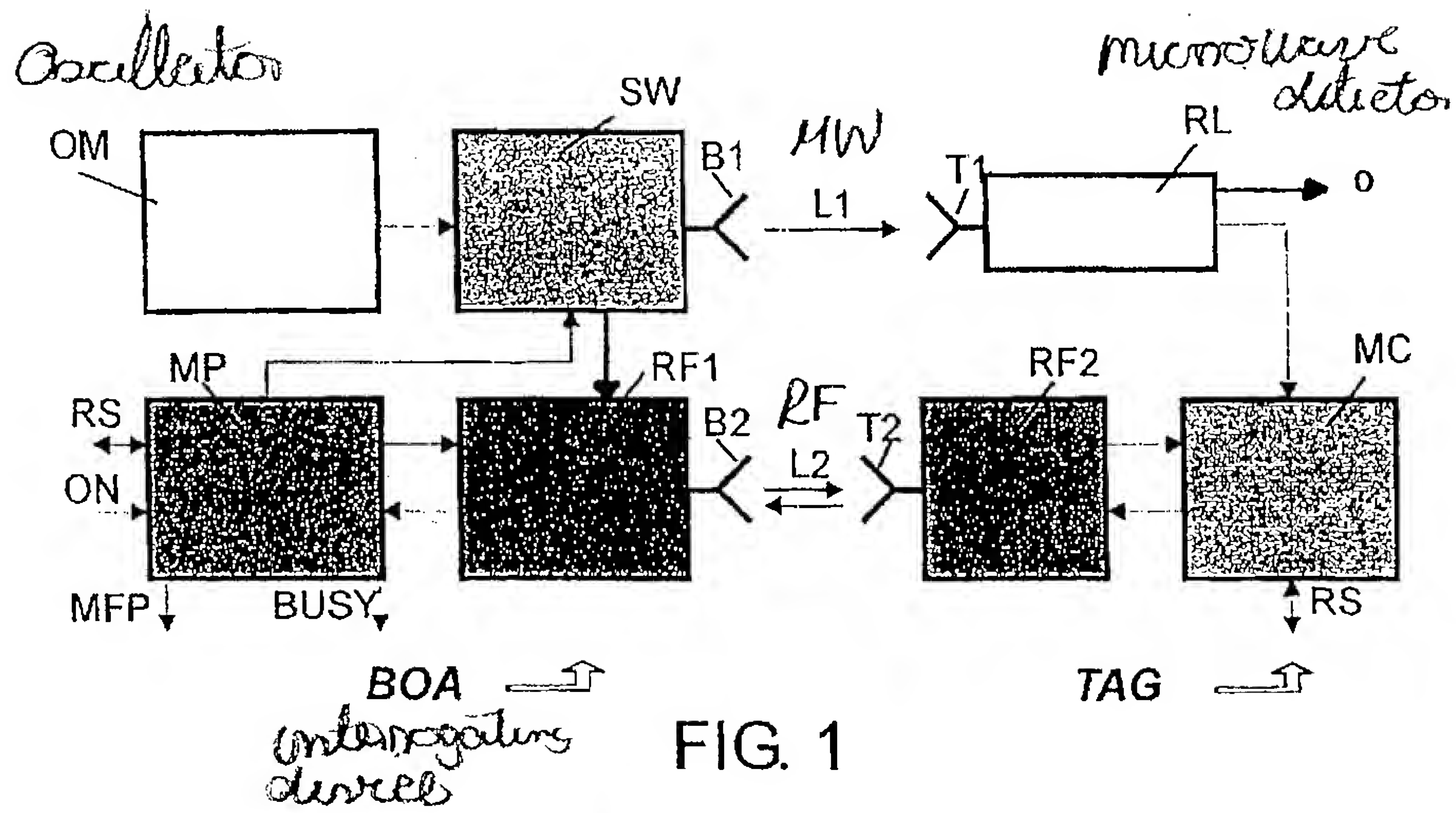

FIG. 1

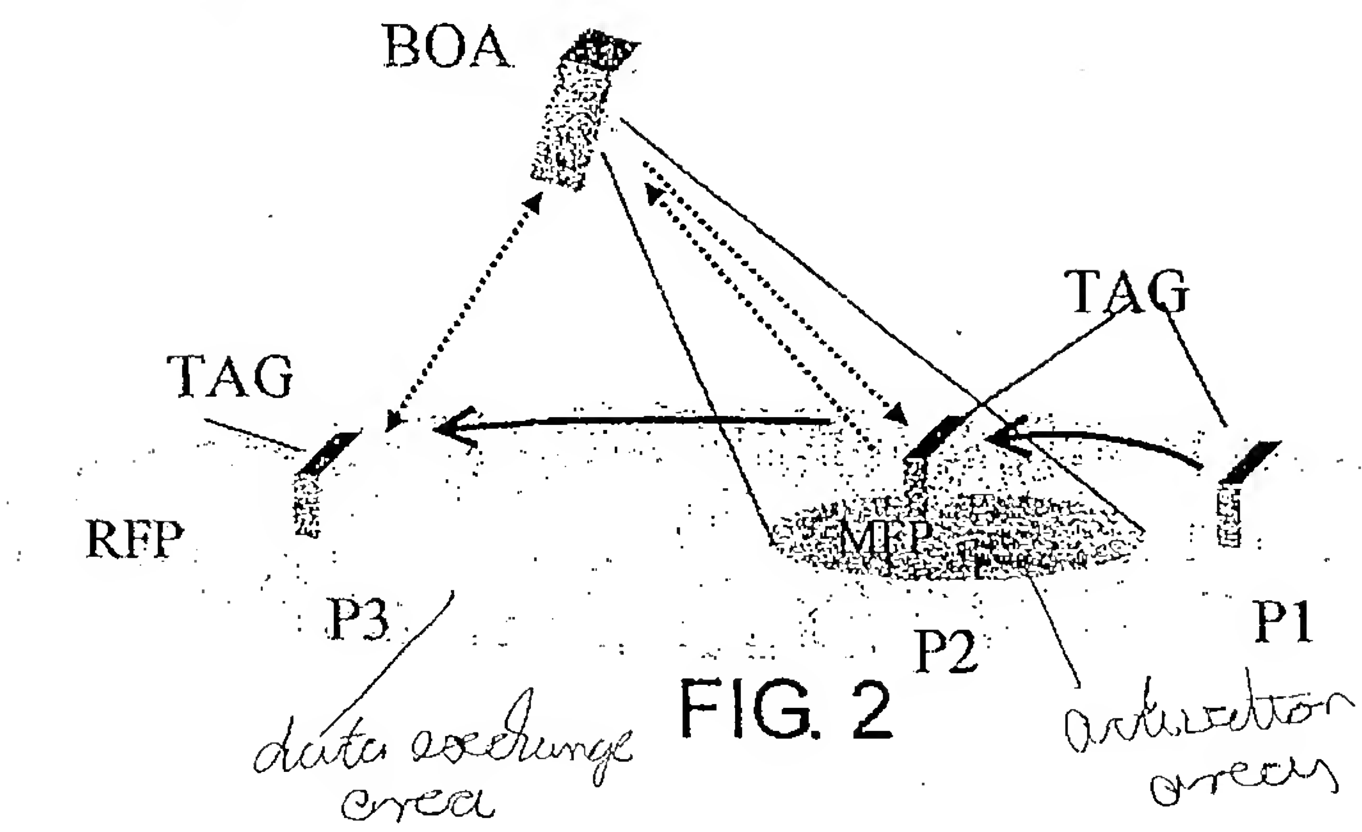

FIG. 2

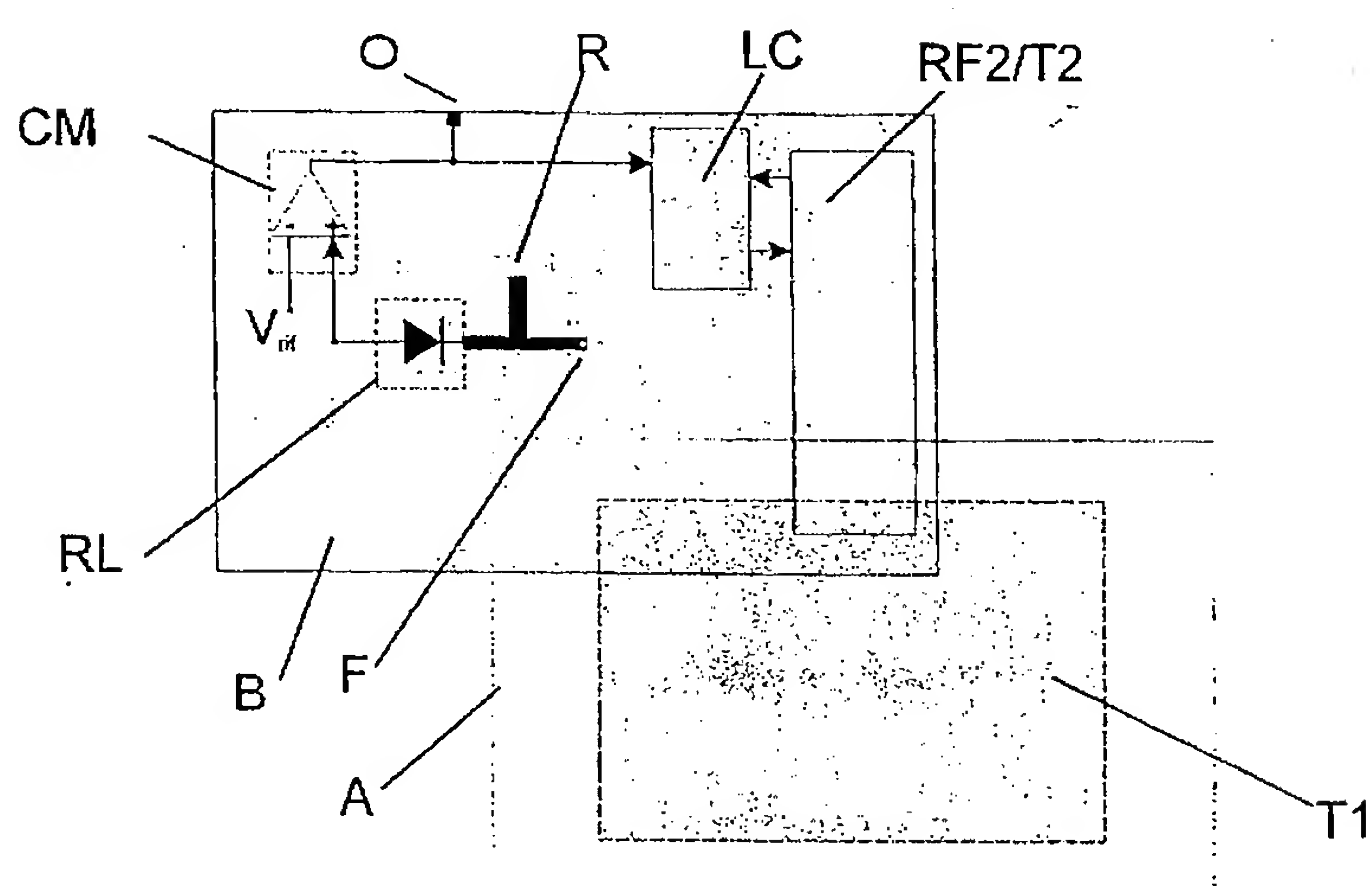

FIG. 3